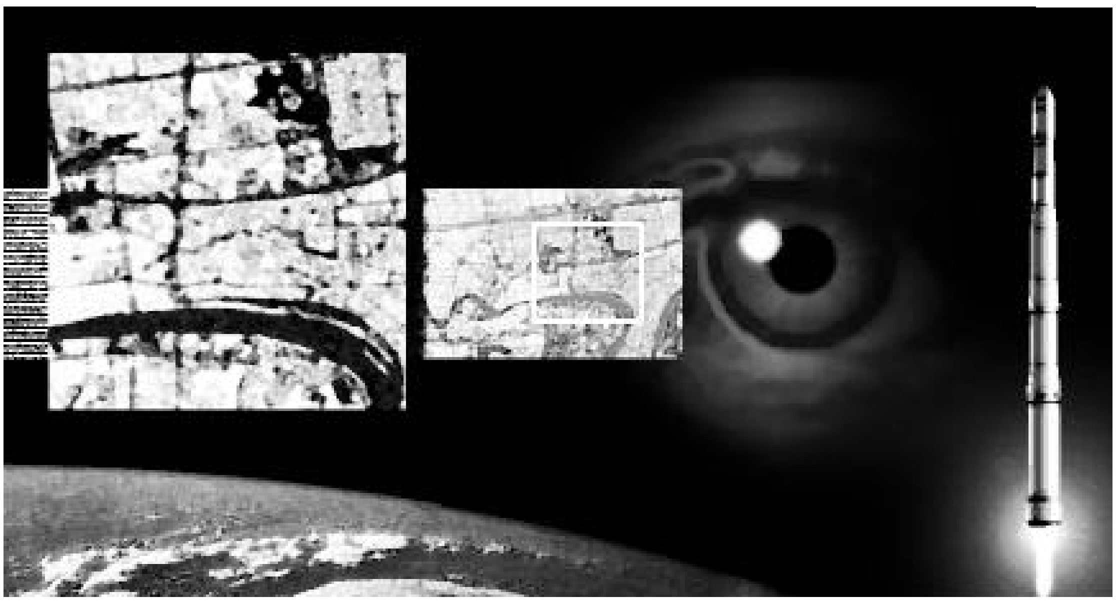
Sentinels Rising

Commercial High-Resolution Satellite Imagery and Its Implications for US National Security



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Whereas I was blind, now I see.

—John 9:25
Authorized (King James) Version

ON 24 DECEMBER 1997, at the Svobodnyy Cosmodrome situated in a far corner of eastern Siberia, a modified Russian SS-25 intercontinental ballistic missile arched skyward, but rather than the single thermonuclear weapon

*Although the proliferation of ballistic missile technology is beyond the scope of this study, the growing market for commercial space activities, including spacelift, also has very serious implications for US national security. As an aside, *Start-1* roughly translates something akin to the "go" in English as in "Ready, set, go!" It is not related to the commonly used acronym for the *Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Reduction and Limitation of Strategic Offensive Arms of July 31, 1991* (the START Treaty).

*******High-resolution* is a relative term, but as it is used by this study describes satellite-imaging systems capable of providing order-of-magnitude improvements in spatial resolution over earlier systems.

it was originally designed to deliver, it carried a peculiar cargo—a US-made imaging satellite.* The owner of the satellite, EarthWatch, Inc. of Longmont, Colorado, contracted with Russia to boost its EarlyBird 1 spacecraft into polar orbit using a Start-1 space launch vehi-

Table 1

Land-Imaging Satellites Planned to be Operational by 2000

SYSTEM	OWNER	SENSOR	LAUNCH DATE	SPATIAL RESOLUTION (METERS)									STEREO TYPE	SWATH (km)	GLOBAL REVISIT (DAYS)
				PAN	THEMATIC MAPPER BANDS							RADAR			
					VISIBLE AND NEAR IR				SHORT-WAVE IR		THERMAL IR				
					1	**2**	**3**	**4**	**5**	**7**	**6**				
MULTISPECTRAL															
IRS-1C, D	India	M & P	95, 97	6		23	23	23	70				C/T	70, 142	48, 24
IRS-P5, IRS-2A	India	M	98, 99			6, 23	6, 23	6, 23	23				C/T	25, 142	125, 22
SPOT 4	France	M & P	98	10		20	20	20	20				C/T	120*	26
CBERS	China & Brazil	M & P	98, 99	–, 8	20	20	20	20	80	80	160		C/T	120	26
Landsat 7	US	M & P	98	15	30	30	30	30	30	30	60			185	16
EOS AM-1	US & Japan	M	98			15	15	15	6 bands @ 30		5 bands @ 90		F/A	60	49
R21A, B, C, D	Resource 21	M	2000		10	10	10	10	20					200*	4†
HIGH-RESOLUTION															
EarlyBird 2	EarthWatch	M & P	98	3		15	15	15					F/A	36	120
IKONOS 1, 2	Space Imaging	M & P	98, 99	1	4	4	4	4					F/A	12	247
QuickBird 1, 2	EarthWatch	M & P	98	1	4	4	4	4					F/A	20	148
OrbView 3	ORBIMAGE	M & P	98, 99	1 & 2	8	8	8	8					F/A	4 & 8	740, 370
SPIN-2	Russia	P‡	96, 97	2, 10									F/A	180, 200	
Eros-A	West Indian Space	P	98	1.5									F/A	14	211
Eros-B	West Indian Space	P	99	1									F/A	20	148
IRS-P6	India	P	99	2.5									F/A	10	296
HYPERSPECTRAL															
EO-1	US	H & M	99		128 bands @ 30				256 bands @ 30					15	200
HRST	US	H	2000	5	210 bands @ 30									30	100
ARIES	Australia	H	2000	10	32 bands @ 30				32 bands @ 30					15	200
RADAR															
RADARSAT	Canada	SAR	95									10 C-band		50–500	
ERS	ESA	SAR	98									25 C-band		100	

Legend:

P = Panchromatic
M = Multispectral
H = Hyperspectral
SAR = Synthetic Aperture Radar
C/T = side-side stereo
F/A = fore/aft stereo
*Swath is achieved by two side-by-side instruments
†Four (4) satellites are planned to provide 3.5–4 day-global repeat coverage
‡Photographic film return system

Source: William E. Storey, "Outlook for the Future: Land Sensing Satellites in the Year 2000," chapter 20 in *The Remote Sensing Tutorial Online Handbook,* by Nicholas M. Short (Greenbelt, Md.: Goddard Space Flight Center, 1988), table 9.

cle.[1] As the first of an entirely new generation of high-resolution** commercial imaging satellites, EarlyBird 1 was postured to make history.[2] Unfortunately, soon after the satellite settled into its low-Earth orbit (LEO), a problem developed with its communications system that has prevented EarthWatch from issuing commands to the satellite, and EarlyBird 1 is nonoperational.[3]

The false start of the first EarlyBird 1 satellite marked a rather inauspicious beginning to what the commercial remote-sensing industry hopes will quickly become a thriving, multibillion dollar market in the years ahead. Private remote-sensing firms are racing to get their high-resolution imagery satellites into orbit and imagery into the hands of consumers. Despite the daunting technical and financial risks, industry watchers predict that by mid-2001, over 30 satellites will be in orbit around the Earth using affordable technologies to provide volumes of imagery to an international clientele with fidelity previously unobtainable by the general public (see table 1 for system comparisons).[4] No longer will the United States and the former Soviet Union enjoy their hegemony over satellite imaging of the Earth. Instead, they must share their vantage point of Earth from the ultimate "high ground" with other nations as a fleet of mercantile sentinels rises to provide high-resolution imagery to customers around the world.

The Military Challenges of the Year 2000 Constellation

The Clinton administration issued Presidential Decision Directive INSC-23 (PDD-23), entitled "U.S. Policy on Foreign Access to Remote Sensing Space Capabilities," on 9 March 1994. It established the policy framework to boost the nascent American remote sensing market so it could compete with foreign providers of high-resolution imagery.[5] It also piggy-backed on the groundwork already laid by the Land Remote Sensing Act of 1992 (P.L. 102-555), which, inter alia, recognized that "the national interest of the United States lies in maintaining international leadership in satellite remote sensing."[6] More important, PDD-23 reversed earlier policy that had sought to restrict commercial entry into the remote-sensing market. By liberalizing US licensing procedures, the White House and Congress formally acknowl-edged that not only had the geopolitical landscape fundamentally changed, but there was simply no easy way to get the "genie back into the bottle" with respect to the proliferation of satellite imaging technology.[7]

Spatial Resolution and Military Utility

To appreciate the security challenges brought about by current and planned commercial imaging satellites, it is instructive to survey what the first-generation reconnaissance satellites accomplished for the United States. The highly classified Corona project, operating under cover as the Discoverer space flight program, began in August 1960 and in little more than a decade collected over 800,000 images over "denied territory" that finally lifted the veil of secrecy from the USSR that had stymied accurate assessments of Soviet strategic capabilities.[8] With its broad area coverage and reasonably good spatial resolution (two to 11 meters), Corona debunked the myth of a "missile gap" by providing the Eisenhower administration with incontrovertible evidence that Soviet offensive missile strength had been significantly overestimated. Based on this information, Eisenhower confidently rejected pleas for an American buildup of its long-range missile force to close a gap that was merely illusory.[9] Like Corona, the commercial systems that will soon be in orbit also hold enormous potential for performing a wide range of intelligence, surveillance, and reconnaissance (ISR) tasks.

Table 2 provides a sense of what level of spatial resolution is required for ISR using com-

*Targeting is closely related to the ability to detect and precisely identify the given object or location.

Table 2

Ground Resolution (in meters)

TARGET	DETECTION[a]	GENERAL ID[b]	PRECISE ID[c]	DESCRIPTION[d]	TECHNICAL ANALYSIS[e]
Bridges	6	4.5	1.5	1	0.3
Radar	3	1	0.3	0.15	0.015
Supply Dumps	1.5–3.0	0.6	0.3	0.03	0.03
Troop Units (in bivouac or on roads)	6	2	1.2	0.3	0.15
Airfield Facilities	6	4.5	3	0.3	0.15
Rockets and Artillery	1	0.6	0.15	0.05	0.045
Aircraft	4.5	1.5	1	0.15	0.045
Command & Control HQ	3	1.5	1	0.15	0.09
Missiles (SSM/SAM)	3	1.5	0.6	0.3	0.045
Surface Ships	7.5–15	4.5	0.6	0.3	0.045
Nuclear Weapons Components	2.5	1.5	0.3	0.03	0.015
Vehicles	1.5	0.6	0.3	0.06	0.045
Minefields (land)	3–9	6	1	0.03	0.09
Ports and Harbors	30	15	6	3	0.3
Coasts and Landing Beaches	15–30	4.5	3	1.5	0.15
Railroad Yards and Shops	15–30	15	6	1.5	0.4
Roads	6–9	6	1.8	0.6	0.4
Urban Areas	60	30	3	3	0.75
Terrain	–	90	4.5	1.5	0.75
Submarines (surfaced)	7.5–30	4.5–6	1.5	1	0.03

Sources: Senate Committee on Commerce, Science, and Transportation, *NASA Authorization for Fiscal Year 1978,* 1642–43; and *Reconnaissance Handy Book for the Tactical Reconnaissance Specialist* (St. Louis, Mo.: McDonnell Douglas Corporation, 1982), 125.

[a] Detection: Location of a class of units, objects, or activity of military interest
[b] General Identification: Determination of general target type
[c] Precise Identification: Discrimination with target type of known types
[d] Description: Size/dimension, configuration/layout, component construction, equipment count, etc.
[e] Technical Analysis: Detailed analysis of specific equipment

monly accepted ground resolutions required to detect, identify, describe, and analyze those targets.[10] With the advent of one-meter ground-sample distance (GSD) panchromatic sensors as the current performance benchmark, nearly 60 percent of the table's military intelligence tasks, and 85 percent of the targeting-related tasks can now be satisfied.* Of course, these figures merely represent a rough approximation of what military requirements could be met since there are many other system performance factors that must be considered, including imagery timeliness and frequency of coverage (see the following discussion of the US Space Command study Operation Seek Gunfighter).

Carnegie Study

Obviously, one-meter GSD imagery data offers substantial military utility, but the threat is not only confined to those systems with the best spatial resolution. The Carnegie Endowment for International Peace conducted a study in the late 1980s that evaluated the military utility of Landsat, *Système pour l' observation de la Terre* (SPOT), and Soyuzkarta

Table 3

Ground Resolution (by sensor system)

TARGET	DETECTION[a]	GENERAL ID[b]	QUANTITATIVE MEASUREMENTS[c]
Bridges	MSS/TM	TM/XS	XS/P
Roads	MSS	MSS	TM/XS
Radar	P	P	–
Railroads	MSS	P	–
Supply Dumps	MSS	P	P
Major HQ	MSS	TM/P	P
Airfield Facilities	MS	TM	P
Aircraft	P	P	P
Rockets and Artillery	MSS/TM	XS/P	–
Missiles (SAM)	MSS	MSS/TM	P
Surface Ships	XS	XS	XS/P
Submarines (surfaced)	TM	XS/P	P
Vehicles	P	–	–

Legend:
MSS: Landsat multispectral scanner (80-meter GSD)
TM: Landsat thematic mapper (30-meter GSD)
XS: SPOT extended spectrum sensor (20-meter GSD)
P: SPOT panchromatic sensor (10-meter GSD)

Source: Peter D. Zimmerman, "Introduction to Photo-Interpretation of Commerical Observation-Satellite Imagery," In *Commerical Observation Satellites and International Security,* Michael Krepon et al., eds. (London: The Macmillan Press Ltd., 1990), 203.

Note: No attempt was made to list all targets in the original chart (See *Reconnaissance Handy Book for the Tactical Reconnaissance Specialist* [St. Louis, Mo.: McDonnell Douglas Corporation, 1982]), 125.

[a] Detection: A target of the given type is clearly present, but no details are apparent.
[b] General Identification: Classes and numbers of objects can be discerned; little or no doubt the target has been properly classified.
[c] Quantitative Measurement: Quantitative measurements of the target can be made. Objects classified by mission or type.

KFA-1000 (now Spin-2) imagery. Surprisingly, the imagery analysts discovered that using SPOT's 10-meter GSD—imagery resolution that will soon be considered only mediocre—enabled them to easily satisfy nearly all the targeting-associated tasks contained in the study's target list. The Carnegie study concluded that commercial satellite imagery is "rich in information which can be used to affect the planning and execution of military operations."[11] As a result, a new table was developed with revised spatial resolution criteria that summarized their findings (table 3).[12]

US Space Command Study

A decade after the Carnegie project, the US Air Force Space Command organized its own assessment of the military utility of commercial satellite imagery. Operation Seek Gunfighter was conducted under the auspices of the Space Warfare Center and its Aggressor Space Applications Project. The Air Force formed a "Red Cell"—a simulated opposing force—which relied exclusively on open-source information and commercial satellite imagery to track the deployment of an air expeditionary force (AEF) to Bahrain in October 1997.[13]

The Red Cell quickly learned a great deal about the AEF deployment from using the Internet without any special Internet access privileges afforded some "dot-mil" sites. For example, they discovered where the AEF would deploy, its mission, and its force composition. Imagery collection was more problematic, however, due to the limited number of commercial satellite resources available. A case in point, the Red Cell knew that the Canadian Radarsat could provide the timeliness

"A valuable intelligence picture can be pieced together using a combination of open source information and satellite imagery."

that was needed, but the satellite was already performing priority collection in Antarctica and could not be retasked, nor could the Indian IRS-1C meet operational deadlines. The team did succeed, however, in tasking SPOT to image the AEF beddown locations in Bahrain, as well as Mountain Home Air Force Base, Idaho.[14] The few SPOT images obtained offered a wealth of information that the Red Cell could not have otherwise obtained. Analysts were able to locate the AEF headquarters, the logistics areas, and a "tent city" for deployed personnel. Additionally, the security perimeter was clearly identified, as were hardened aircraft shelters, refueling areas, and hardstands.[15] The Air Force concluded that "a valuable intelligence picture can be pieced together using a combination of open source information and satellite imagery."[16]

Beyond Spatial Resolution

Given the historical military significance of imaging satellites like Corona and the results of studies like those conducted by the Air Force and the Carnegie Endowment, one wonders why the debate over commercial imagery satellites has focused principally on the issue of spatial resolution. It is vitally important to move beyond the simplistic notion that spatial resolution is the deciding factor as to whether a particular system may pose a threat to national security. In fact, moderate resolution spectral data from multiple sensors may actually present a greater threat than does high-resolution panchromatic imagery alone.

Spectral Information. The commercial sector is clearly heading in the direction of using multispectral imaging for a variety of applications. These extended wavelength bands offer much more information than is available in even the highest-resolution panchromatic image of the same area. As an example, imagery obtained in the near-infrared and short-wave infrared regions of the electromagnetic spectrum can effectively defeat many efforts to use camouflage since these wavelengths can detect subtle changes in the moisture content of vegetation and earthen terrain. Spectral data can also be interpreted more easily by computers than spatial data, facilitating development of expert systems that can automate much of the interpretation process and reduce the burden on scarce human resources.[17]

Synergy. With today's advances in computer technology, it is now possible to use the phenomenology from one sensor, combine it with others, and do so using low-cost workstations running commercially available software applications. This approach makes use of the synergistic effect whereby the amount of information obtained by synthesizing data from multiple sensors exceeds that provided by individual sensors. Many firms already promote capabilities to provide such hybrid products, albeit in a limited fashion. For instance, Space Imaging markets "pan sharpened" multispectral imagery products that are made by merging high-resolution panchromatic imagery with multispectral imagery. The result is an image that contains a wealth of spatial and spectral information that outdistances what either sensor could separately provide.[18]

The GPS Threat. Security concerns over the proliferation of Global Positioning System (GPS) receivers around the world offer a thought-provoking corollary to the questions raised by the emergence of high-resolution commercial imagery satellites.[19] The amazing growth in the use of civilian GPS has caused alarm in the national security arena. By 2005, the Department of Defense (DOD) estimates that the number of civilian GPS users will exceed three million compared with a mere 38,000 DOD users.[20] Government efforts to restrict the quality of GPS data in the interests of protecting US national security have met with controversy similar to that of high-resolution satellite imagery. What is instructive about the GPS case is that market forces provided a unique and thoroughly creative response to government restrictions. The market developed an ingenious workaround, known as *differential* GPS, which uses presurveyed points to assess and compensate for the GPS errors in a particular geographic area. By using this method, geopositional accuracy that rivals the GPS data reserved for the military is possible and should serve as a classic example of how bureaucratic remedies to technical problems can be overcome by a little entrepreneurial ingenuity operating in a free market.[21]

Thinking Precisely. There is one particular GPS application that dovetails with the use of commercial satellite imagery that, over time, could have a profound effect on US national security. Precision agriculture combines the use of GPS with high-resolution multispectral imagery surveys of agricultural lands. Rather than treating crops as if they were homogeneous, farmers who use precision agricultural methods examine satellite imagery to determine precisely what areas need more or less water, fertilizer, pesticides, fungicides, and other elements and then apply what is needed exactly at the right time. The key to precision agriculture is the imagery management infrastructure to interpret the imagery data and make timely recommendations useful to the farmer, who can then use GPS-guided farm implements to precisely apply what the crops need.[22] The precision agricultural process is strikingly similar to what the military has to do when it makes a threat assessment, plans a mission, and targets its weapons.

This similarity may have profound implications for US national security if one accepts the thesis offered by Alvin and Heidi Toffler in their recent work, *War and Anti-War: Survival at the Dawn of the 21st Century*. They contend that "the way we make war reflects the way we make wealth" and provide some thought-provoking insights about how societies differ in their approach to war and peace based on their degree of economic development.[23] First-wave and second-wave societies (i.e., characterized by agriculture and mass production, respectively) that become adept at precision farming could leverage imagery satellite technology and GPS to create their own limited version of a revolution in military affairs. Thus, rather than aspiring to World War II–style armaments and organizational structures, nations (or even terrorist groups) may find it relatively easy to take what they already know about applying pesticides precisely and build a precision strike combat capability.

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Mitigating Factors

Despite the obvious potential commercial satellite imagery holds for militaries around the world, it is not at all clear whether they can readily use satellite imagery. While the ability to collect, process, analyze, and assess information is certainly important, it is only one element of a nation's ability to wage war. Ultimately, a nation with obvious hostile intent and armed with the best satellite imagery available must still be able to convert that information into combat capability. Too often, a potential adversary is viewed as a doppelgänger of the United States rather than taking full account of the profound asymmetries that exist with respect to supporting the war fighter with satellite imagery.

The "Hail Mary" Case. Critics of the US policy to license high-resolution satellite imagery systems have often cited a "what if" scenario based on Operation Desert Storm. If

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Saddam Hussein had had access to satellite imagery prior to and during the Gulf War, they reason that Iraq could have thwarted Gen H. Norman Schwarzkopf's bold "Hail Mary" maneuver by targeting the massed formations of men and materiel of the XVIII Airborne Corps and VII Corps with missiles.[24] The conclusion to be drawn is that for any future employment of US forces a similar scale will be vulnerable to observation by commercial imaging satellites, and as such the forces would be "sitting ducks" for an enemy equipped with missiles and/or weapons of mass destruction.[25]

Political Disbelief. On the other hand, in order to conclude that access to satellite imagery by an adversary will make the difference between military success and debacle assumes some facts not in evidence. One must assume that leaders like Saddam Hussein would actually believe what the commercial satellites detected. However, history is replete with examples where intelligence on an enemy was ignored, discounted, or disbelieved because it ran contrary to the predisposition of decision makers. Richard Betts, a senior fellow at the Brookings Institution, concluded in his study of surprise attacks that "the primary problem in major strategic surprises is not intelligence warning but political disbelief."[26]

It's Just Not That Easy. Few would argue that the United States clearly has a technological and operational advantage with respect to information operations using space-based assets. Yet, despite decades of experience, not even the United States has gotten it quite right when it comes to getting the most from its imagery satellites. For instance, after the Gulf War a number of US "intelligence failures" related to the use of satellite imagery was identified, which included unreliable dissemination of imagery intelligence to air wings and ground units.[27] It is just not that easy to convert information into combat power. Therefore, there is no reason to assume that mere access to satellite imagery automatically confers to the enemy an ability to use that imagery in a manner that substantially alters the balance of power or the endgame.

The Diplomatic Challenges

There is little doubt that the new generation of commercial imagery satellites raises legitimate concerns with regard to their military utility. Nonetheless, their greatest impact upon US national security will likely occur during peacetime, not war, and in the context of day-to-day diplomacy. The oft-quoted military strategist Carl von Clausewitz observed in his 1832 magnum opus, *On War,* that the military act of war (or preparation for war) is inextricably linked to the political and diplomatic processes, which are not mutually exclusive, but rather form a continuum.[28] Therefore, assessing the impact of commercial satellite imagery on US national security also requires a review of how commercial satellite imagery may affect the "art of the state"—diplomacy.

Transparency

Over the past decade, a number of studies have attempted to consider what would happen when superpower dominion over satellite reconnaissance ended. In 1988, one such study by the Carnegie Endowment for International Peace determined that on balance, "the element of strategic transparency provided by readily available commercial images does far more for maintaining peace than it does for sharpening means of attack."[29] Many advocates for loosening restrictions on commercial satellite imagery have since joined the chorus of those who believe that improved transparency provided by commercial imagery will actually lessen the prospects for conflict.

The News Media

About the same time as the Carnegie study, Congress examined issues that involved the media's use of satellite imagery and national security. The reason for the study was that the media was very much interested in developing an independent source of satellite imagery, which included a proposal for construction of a "Mediasat."[30] The Office of Technology Assessment (OTA) report stopped short of the Carnegie study's bottom-line endorsement of commercial imagery satellites. Instead, it concluded that the media's use of them might "*complicate* [emphasis added] certain U.S. national security activities and certain U.S. foreign policies."[31] A number of things have changed since then that could resurrect national security concerns over the media's access to satellite imagery. The proliferation of "all-news" networks like the Cable News Network (CNN) has cut the news cycle from days to hours. Add to that the fact that dozens of satellites will soon orbit the Earth collecting high-resolution imagery around the clock, and that imagery will not only be much more literal than ever before but will be sold at very competitive prices. The result is a coincident convergence of two markets that are highly motivated and ideally suited for each other—a development that will almost certainly result in controversy over national security and freedom of the press.

War and Antiwar

Futurists Alvin and Heidi Toffler offer an even more profound assessment of the security implications of commercial satellite imagery and diplomacy. They predict that diplomats no longer can expect to shepherd the affairs of state exclusively. The *raison d'état* of third-wave societies—information superiority—will become the principal objective and diplomatic currency of citizens groups, businesses, and even religious organizations. High-tech sources of information like commercial satellites will be used by "knowledge warriors" to prosecute new forms of war and antiwar.* This will result in a gradual power shift from the traditional practice of diplomacy by the nation-state to advocacy by citizens groups and individuals.[32] For citizen activists to make a difference, the population at-large must be well informed, thoroughly persuaded, and highly motivated.[33] Although the media will continue to play a central role in informing the public, nongovernmental organizations (NGO) and international governmental organizations (IGO) will themselves seek to inform, persuade, and motivate the citizenry and will use all the tools at their disposal to advance their cause du jour, including commercial satellite imagery.

Public Interest Groups. NGOs and IGOs are not new. According to Dr. Stephen Cambone, a senior fellow at the Center for Strategic and International Studies based in Washington, D.C., about two hundred of them existed at the turn of the last century, but few had any real interest in diplomacy or international relations. Times have changed. The number of NGOs and IGOs has skyrocketed and by 1990, their numbers had peaked at nearly 18,000. While the majority of NGOs and IGOs still remain outside the sphere of international relations, organizations that are concerned with international matters seem to be motivated by their own ethos.[34] As the influence of NGOs and IGOs continues to grow, traditional nation-state diplomacy will be challenged by independent actors who derive their strength not from the state but from public opinion. To remain viable and relevant, these groups must be able to arouse the public and persuasively argue their causes and will certainly turn to powerful tools of persuasion like satellite imagery to seize the initiative, build momentum, and force governmental action.

*The Toffler's define *anti-war* as actions taken to deter or limit war rather than the opposite of war. War itself may be considered antiwar, such as when a "preventive war" is begun to preempt a larger, more destructive form of warfare.

Seizing the Initiative. Unlike public interest groups, governments are hobbled by their own internal policy debates that can slow or derail the well-intended efforts of public officials. NGOs and IGOs, on the other hand, often organize themselves around a single issue and, therefore, do not have to vet their positions to the same degree that governments must. The deliberate tempo of traditional diplomacy, which has been likened to the highly stylized Japanese Kabuki dance, may be replaced by a more frenzied pace caused by these interlopers. On the other hand, it is not clear whether the growing influence of watchdog groups—armed with information derived from high-resolution imagery—is altogether undesirable. One reason for such a view is that there are times the US government simply cannot watch all of the "niche" issues that NGOs and IGOs want monitored. In fact, work done by groups like Human Rights Watch or Greenpeace could actually advance US policy interests by providing timely information in support of US policy. In effect, they could extend the "eyes and ears" of the government on a number of issues.

Arms Control and Verification

Imagery satellites, long considered the bedrock of arms-control monitoring, owe their very existence to the pursuit of verifiable arms control treaties during the cold war. Soviet intransigence with respect to on-site inspections had all but killed any prospects for meaningful arms control between the United States and the Soviet Union until 1962. At that time, the newly created US Arms Control and Disarmament Agency (ACDA) commissioned the Woods Hole Summer Study to consider issues related to verification of arms-control agreements with the Soviet Union. As a result, verification regimes that viewed on-site inspection as the sine qua non of verification were scrapped in favor of agreements that could be verified using "minimum access" methods, otherwise known as National Technical Means, or NTM.[35]

The diplomatic currency of American NTM during the cold war is legendary and has resulted in the creation of a certain mystique regarding the true capabilities of America's spy satellites. The mystery of spy satellites has captured the imaginations of Hollywood, the public, and is a matter of great interest abroad. Given the highly classified protection afforded information about these satellites and the imaginations of screenwriters and reporters, other countries would find it nearly impossible to separate fact from fiction, hypothesis from hyperbole. In response, foreign governments may employ commercial imagery satellites to gauge their activities with what they believe American NTM can detect. If successful, this could seriously affect the ability of the United States to verify compliance with arms-control agreements.

Poor Man's NTM. As commercial satellite imagery becomes increasingly commonplace, the mystique long associated with superpower NTM will eventually diminish. Such a development would not be altogether negative, however. Nations that have previously resisted the use of NTM to verify arms-control agreements might finally agree to its use since they would have direct access to their own source of satellite imagery—a sort of "poor man's NTM."[36] On the other hand, it may be difficult to convince them to trust commercial imagery suppliers that hail from another country, particularly with respect to American firms that are currently or have formerly been associated with the Pentagon or the intelligence community. Skeptical foreign governments might then turn to providers with less political baggage, or may even reject verification regimes based on commercial imagery altogether.

New Players and "Noise." Commercial satellite imagery will also affect the world of arms-control verification and compliance diplomacy as a new set of players will emerge empowered with their own "eyes in the sky."[37] These players will include NGOs and IGOs, as well as "white hat" countries like Canada, Sweden, Australia, and the Netherlands.[38] Increasing the number of players with access to high-resolution satellite imagery will un-

A Delta II carries a Global Positioning System (GPS) Satellite into orbit in 1996. Security concerns over the proliferation of GPS receivers around the world offer a thought-provoking corollary to the questions raised by the emergence of high-resolution commerical imagery satellites.

doubtedly elevate the "noise" level with respect to compliance assessments. A 1996 study prepared by Science Applications International Corporation concluded that with a new cast of players and attendant increase in noise, the compliance process will be affected by premature revelations, false alarms, increased ambiguity, use of stalling tactics, and self-serving political agendas.[39] By increasing the noise level, differentiating between proscribed and permitted activities may become even more difficult since assessing compliance invariably requires attempting to prove a negative (i.e., that a certain proscribed activity is *not* taking place).[40]

Effective Verification. The noise issue is critically important to the United States because of its exacting "effective verification" standard. A treaty is considered to be effectively verifiable if the United States believes that it can detect any militarily significant breach of the agreement and do so in time to respond effectively and deny the other party any material benefit from the violation. Under the rubric of effective verification, it is assumed that violations will be met with some level of US response.* Consequently, the standard of evidence required to "prove" noncompliance is incredibly demanding. After detection, the evidence must survive the withering fire of skeptics and apologists who often insist on incontrovertible proof during the interagency review process. Beyond those requirements, however, evidence of noncompliance must also be innately credible and easily understood by policy makers so they can formulate and justify an effective response to violations.[41] If the evidence is ambiguous and fails to persuade policy makers that a proportional response is warranted, not only can the verification regime be undermined, but the agreement itself could also unravel.

Deception. The exacting standard of evidence required for compliance assessments may be politically necessary, but some coun-

*The United States could respond to violations with any or all of its instruments of national power. Depending on the significance of the violation, the United States could protest diplomatically by demarche, raise the issue publicly, levy economic sanctions, or even conduct military operations against the violator.

tries may view it as a tacit invitation to cheat on their agreements. They do not have to conceal proscribed activities or equipment completely from US observation, but merely create enough ambiguity that the activity is lost in the noise. Creating just that level of ambiguity is the role of *maskirovka,* a Soviet military term that most closely equates to that of the English concept of "deception" but includes camouflage, cover, decoys, feints, disinformation, and information denial.[42] The Soviets were masters at it, and during the cold war, the implications it held vis-à-vis strategic stability were enormous. The principal challenge to arms controllers during that era was designing an agreement that could prevent Soviet cheating. Amrom Katz, an arms-control legend and father of NTM, underscored the verification challenge in a manner worthy of Yogi Berra when he testified before Congress, "We have never found anything that the Soviets have successfully hidden."[43]

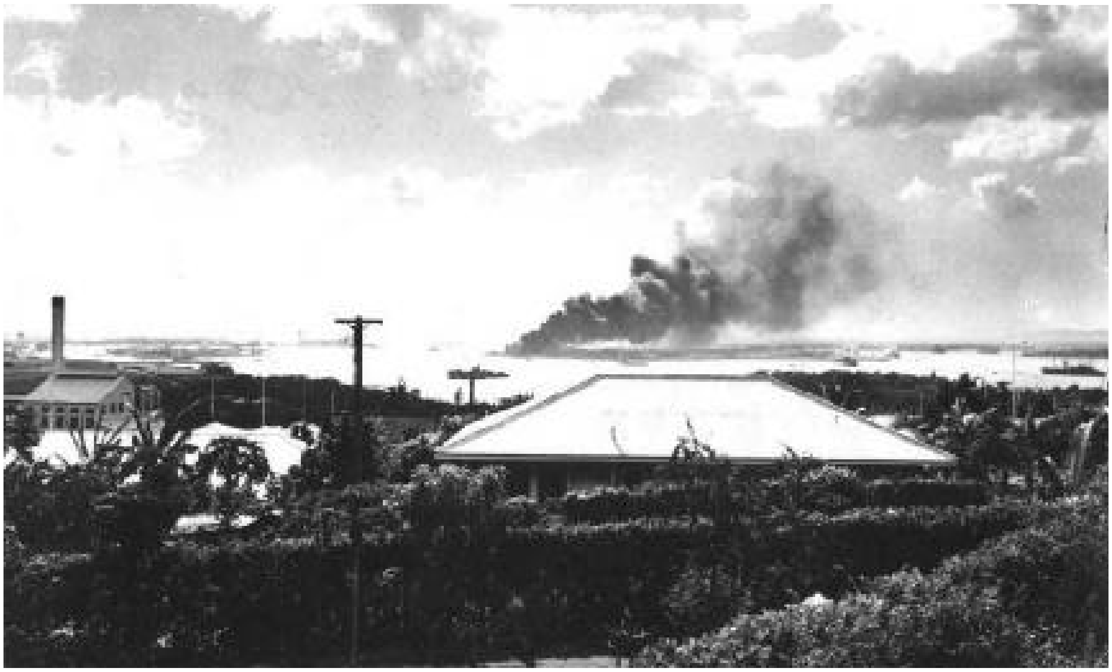
Incentives to Cheat. Deception is still a concern of the present generation of arms controllers, and in some respects, they have a much more difficult job than did the cold warriors. Today's international environment is no longer dominated by superpower rivalry, but is characterized by regional disputes that require multilateral solutions. Asymmetries abound. Not even the former Soviet Union can match the United States in terms of its broad economic, political, or military power. Consequently, there are tremendous pressures in many regions to level the geopolitical playing field, creating incentives to cheat on arms- control agreements.

The Kennedy administration found that "verification acts as a deterrent to evasion only to the extent that a potential violator is concerned with the risks of exposure."[44] Accordingly, would-be violators would be well advised to fully assess their risk of exposure and develop methods to avoid detection. As states become more familiar with what can be seen by imagery satellites (and what cannot), there is a chance that some will use their newfound knowledge to risk cheating. On the other hand, there is no clear-cut answer to whether the availability of commercial satellite imagery will influence a country's decision to cheat by supporting its deception efforts because fear of detection is but one element of such a calculation. The other and more important element is national self-interest, and as ACDA concluded long ago, "National self-interest, rather than fear of detection, will remain the principal inducement to compliance."[45]

The Opportunities

One outgrowth of private investment in commercial satellite imagery systems involves the potential for spin-off. The term *spin-off* refers to technology developed for the military that might have some commercial application down the road. For example, much of the impetus for the new generation of commercial imaging satellites resulted from research done for the Strategic Defense Initiative (SDI).[46] Although spin-off technologies from SDI investments jump-started the interest in the high-resolution remote sensing industry, diminishing defense budgets will no doubt lessen the impact that military spending has on future technological developments. Nowhere is this more true than in information systems, where defense spending has generally played only a minor role in the explosive growth of computers, digital data storage, and high-speed communications.[47]

What this means is that the tables may have turned with respect to spin-offs as technology originally developed for the private sector may now serve as the touchstone for government systems. This has largely already come about in the area of electro-optical sensors, as well as computers and mass storage that are critical elements of any digital imagery system.[48] To stay competitive, firms will have to prove their agility and creativeness in order to come up with better products and deliver them at lower costs to the customer. Therefore, the principal dynamic at work in the space reconnaissance business may well result from corporate effort to improve the "bottom line" for shareholders and not the National Reconnaissance Office.[49]



Pearl Harbor, December 1941. To conclude that access to satellite imagery by an adversary will make the difference between military success and debacle assumes some facts not in evidence. Richard Betts, a senior fellow at the Brookings Institution, concluded in his study of surprise attacks, "The primary problem in major strategic surprises is not intelligence warning but political disbelief."

US Plans for Commercial Imagery

Notwithstanding the policy goals enunciated by PDD-23 and the demonstrated value to military operations during the Gulf War, there are some government imagery analysts and policy makers that are less than enthusiastic in their approach toward commercial satellite imagery. This may be the result of either misapprehension of the true potential of these systems, or perhaps simply reflect nervousness with the prospect of bankrolling an industry that can make life much more difficult for those involved in national security. On the other hand, many in government recognize that this technology is here to stay, and integrating it with the overall national imagery architecture could offset some known shortfalls in US space surveillance and reconnaissance capability. While the planned fleet of commercial imaging satellites could certainly address some collection shortfalls, the one area that has received much less attention but holds much greater potential is the so-called back-end problem.

The Back-End Problem. Adm William O. Studeman, former deputy director of the Central Intelligence Agency, acknowledged that the government has placed too much emphasis on the "collection apparatus—its physical attributes, orbits, bells, and whistles" and not enough on how the data is processed, analyzed, and disseminated after it has been collected.[50] The myriad of activities needed to capture, process, analyze, produce, and disseminate information from imagery satellites is known as the system's back end. Unlike the government, working end-to-end solutions is the forte of private enterprise, where market opportunities and cost-cutting drive innovation. Private companies will inevitably seek to improve their market share by devising innovative solutions to the back end of the imagery cycle that will make imagery more relevant and easier to use for their customers.

NIMA Charts Its Course. To its credit, the National Imagery and Mapping Agency (NIMA) has already taken several steps in an effort to tap into the innovative expertise of the marketplace. It recently completed its very first strategic plan and placed the use of commercial satellite imagery at the top of its list of strategic objectives.[51] Indeed, before its release, the former director of NIMA, Rear Adm Jack Dantone said of commercial imagery:

> We're committed to it not because it's the right thing to do politically but because it's the right thing to do. It will probably *supplant* [emphasis added] some of the requirements that we have for other imagery, and that can only be good.[52]

It is interesting to note that while it is generally thought that commercial satellite imagery will be used extensively for geospatial applications, the presumption is that it will play less of a role for classical intelligence functions. This is because "intelligence uses often require imagery resolution and timeliness that exceed the advertised capabilities of commercial satellite systems."[53] Some analysts and even end users remain skeptical of using commercial imagery for ISR tasks despite the obvious policy contradiction inherent in such a view. Current US policy clearly regards the use of commercial satellite imagery by foreign intelligence services as a genuine threat to national security.

Issues

The fundamental goal of current US remote sensing policy "is to support and to enhance US industrial competitiveness in the field of remote sensing space capabilities while at the same time protecting US national security and foreign policy interests."[54] The principal challenge is how to protect US national security interests without inadvertently stunting the growth of the very industry the new policy is intended to promote.

Shutter Control

In order to manage the attendant risks to US national security, both the Land Remote Sensing Policy Act of 1992 and PDD-23 rely on the possible restriction of data collection and/or dissemination.[55] Termed *shutter control*, perhaps no other single issue is more controversial than this cornerstone of current US policy vis-à-vis commercial high-resolution imaging satellites. Although meant to address the serious issues of operational security and force protection, there are obvious problems with US shutter-control policy. Alternative sources for imagery data already exist from a variety of foreign providers. Additionally, there is no guarantee that US remote-sensing providers will dominate the market as the international providers of choice. The implication for US policy is simple: Overzealous use of shutter control will drive away customers who will seek alternative sources of data rather than subject themselves to the whims of American bureaucrats.[56]

Prior Restraint. Even before such market adjustments occur, however, attempts to cap the shutters of American remote sensing satellites might be challenged in the courts. The day after PDD-23 was issued, David Bartlett, president of the Radio-Television News Directors Association, fired a warning shot when he notified key congressional leaders that the wording of the government's shutter-control policy fails to establish "a clear and present danger."[57] A clear and present danger is the burden of proof offered by Justice Oliver Wendell Holmes as the only compelling justification for the federal government enforcing "prior restraint" on fully protected speech.[58] According to the doctrine of prior restraint, the government cannot limit speech protected under the First Amendment "predicated on surmise or conjecture that untoward consequences may result." Supreme Court case law suggests that prior restraint is only necessary to prevent "direct, immediate, and irreparable damage to our Nation or its people."[59]

Legal scholars believe that the issue of shutter control will be brought before the court sooner rather than later, and when it is, the government will find it difficult (some say impossible) to make a case that prior restraint is the most obvious remedy.[60] Others contend that commercial imagery and imagery-derived information does not even qualify for full protection under the Constitution. They argue that the First Amendment was crafted to protect freedom of speech and of the press, shielding expression of opinion, advocacy, and dissent from governmental censorship. Although data deserves some measure of protection from wanton censorship or governmental restrictions, they reason it does not require the same degree of protection as speech.[61] Moreover, the US government already has several postpublication remedies under existing federal law to address such issues as espionage and distributing photographs of defense installations.[62]

International Considerations. Aside from domestic legal concerns, there are a number of international concerns that could further confound the US policy of shutter control. Ever since the first Landsat was launched, the United States has endeavored to provide generous open and nondiscriminatory access to Landsat imagery. By adhering to the principles of "open skies" and nondiscriminatory access to remote-sensing data, the United States has put into practice the very principles embodied in international agreements related to the commercial use of space. As an added bonus, the United States was able to establish the bona fides for overflights made by remote-sensing satellites in general, including its intelligence systems.[63]

Excessive use of shutter control could change all of that. Developing nations that come to depend upon commercial satellite imagery as a critical commodity will most likely take a dim view of US government efforts to exercise shutter control that could deny them the very information upon which they have come to depend. Sensed states might even find that the US action was in contravention of the UN's remote-sensing principles for having conducting remote-sensing activities "in a manner detrimental" to the rights of lesser-developed nations.

No Panacea. Even if the policy survives domestic court challenges, shutter control will certainly be cumbersome to implement for any length of time given the scope of US national security interests, the number of different companies, the variety of sensors in orbit, and the fact that the US military and intelligence communities will increasingly use commercial imagery. Even limited use of shutter control could drive customers away from American-flagged satellites in favor of foreign competitors. Shutter control, therefore, cannot be viewed as a panacea for addressing the security concerns of this country with respect to satellite observation of sensitive operations. In fact, it may turn out to be a blunt instrument that could seriously harm the country's long-term security interests more than it protects them.

The United States must do more to preserve its advantage in the military use of space for information operations and other military tasks by protecting its space assets—including commercial satellites—from attempts to attack or degrade them.

Space Control

Andrew F. Krepinevich, the executive director for the Center for Strategic and Budgetary Assessments and a member of the National Defense Panel, noted that in the panel's report, *Transforming Defense: National Security in the 21st Century*, protection of all the nation's space assets was a principal concern. One reason the NDP highlighted the issue was that DOD has estimated 70 percent of military space requirements will migrate from military to commercial platforms in the next decade. Consequently, the United States must do more to preserve its advantage in the military use of space for information operations and other military tasks by protecting its space assets—including commercial satellites—from attempts to attack or degrade them.[64] Gen Howell M. Estes III, commander in chief of US Space Command, echoed the cautionary theme of the National Defense Panel during recent testimony before Congress. He underscored just how dependent US policy makers, the intelligence community, and military planners have become on satellites and that America must actively pursue measures to "guard against turning [that] dependence into a vulnerability."[65] While there appears to be general agreement with such an assessment, the White House and Congress are divided on just what to do about US vulnerabilities in space.[66]

Satellite Legitimacy and Immunity. Satellite vulnerability is closely linked to the legal status of satellites. One of the great ironies of the cold war is that the United States and the Soviet Union implicitly cooperated to facilitate satellite reconnaissance of each other's territories despite the obvious contradictions inherent in such a policy. While the Soviet Union initially objected to American satellite overflights, Soviet opposition softened as the Kremlin began to see results from its own satellites, which Moscow found particularly valuable with respect to its on-again, off-again relationship with China.[67] So, over time the two superpowers established a "practice of the parties" as the legal basis for legitimizing the use of satellites for reconnaissance—an unspoken and unrecorded "gentleman's agreement" that respected the immunity of each other's reconnaissance satellites.[68]

The legal status of satellites is difficult to determine for the same reason that has stymied efforts to control other technologies that can be used for military and civil purposes. Satellites are clearly "dual-use" technologies that can perform multiple missions using the same spacecraft. Some states have argued that immunity should be granted only to satellites that perform purely peaceful functions or otherwise contribute to strategic stability, excluding satellites that perform surveillance and reconnaissance, early warning, and any other satellites that support military operations. Critics argue against this approach because it is difficult to parse the functionality of satellites, not to mention the complexities associated with verifying compliance with any agreement based on it. Instead, some states favor embracing the principle of global immunity for all Earth-orbiting satellites.[69]

Noninterference. Prior to 1972, there had been no specific ban on interfering with a nation's satellite systems until the United States and the former Soviet Union agreed on NTM-based verification of the Strategic Arms Limitation Talks (SALT) I accord and the Antiballistic Missile (ABM) Treaty. Paragraph 2 of Article XII of the ABM Treaty states that "each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article."[70] As a result, an international norm became firmly established by the superpowers that legitimized the use of satellites insofar as they legally acknowledged the need to verify compliance with arms control as the raison d'être for space-based reconnaissance. With growing international dependence on commercial imagery satellites, the United States might witness renewed efforts by the international community to protect commercial satellites from "harmful interference" pursuant to Article IX of the Outer Space Treaty. Moreover, should commercial satellites ever become de facto NTM for nonspace-faring nations, future arms-control agreements may have to include a "noninterference" provision to protect "poor man's NTM" to the same degree as the United States and the former Soviet Union enjoy under Article XII of the ABM Treaty.

ASAT and the ABM Treaty. One final issue related to space control and satellite vulnerability is the proposition that the United States might use antisatellite (ASAT) weapons to counter foreign commercial-imaging satellites during times of crisis or military conflict. President Bill Clinton made history as the first US president to use the line-item veto, targeting three ASAT programs with his pen, including the Army's Kinetic Energy Antisatellite Program. According to Robert Bell, special assistant to the president and senior director for defense policy and arms control on the National Security Council (NSC), although the administration recognizes the need for space control, it "doesn't necessarily believe at this time that the Army program is the appropriate solution." The White House would rather forgo attacking the satellites themselves, and instead find ways to destroy or disrupt the information downlinked by the satellites.[71]

The Nexus. One of the principal reasons for NSC opposition to ASAT programs is the inextricable link between ASAT weapons and the 1972 ABM Treaty. The Clinton administration reaffirmed the traditional interpretation of the treaty, which prohibits the development, testing, and deployment of sea-based, space-based, and mobile land-based ABM systems regardless of the technology they would use. The reason for the connection between ASAT weapons and the ABM Treaty is because many of the ASAT employment concepts against low-Earth-orbiting satellites would also be useful if used against intercontinental ballistic missiles during the lengthy midcourse phase of their trajectories. Even though there is no international treaty that specifically bans the development, testing, and deployment of ASAT weapons per se, critics fear that ASAT programs could be used as covers for development of illegal ABM technologies that are severely restricted by the ABM Treaty.

Unfortunately, the crossover between ABM and ASAT does not end with the ABM Treaty, but affects the US relationship with the Russian Federation and the START treaties. Russia has explicitly linked the inviolability of the ABM Treaty with its commitment to full implementation of START I, ratification of START II, and START III negotiations for even deeper nuclear force reductions. Although efforts to counter the threats posed by foreign commercial imagery satellites using ASAT weapons may be legitimate, they nonetheless may threaten the delicate strategic relationship with Russia.

Conclusions and Policy Alternatives

Imagery is powerful, persuasive, and poignant. Within the photographic image lies a wealth of information that can transcend the mere representation of reflected photons. Not only can images record an event frozen in space and time, they inform authoritatively and are presumed to offer immutable representations of fact. Moreover, images can often evoke an emotional response from those who view them. Recall for a moment the image of the Earth taken by the Apollo 8 astronauts as they orbited the Moon on Christmas Eve 1968. It was a spectacular image—Earth set adrift in the blackness of space that quickly came to symbolize the global context in which mankind lives. "Think globally, act locally!" became the mantra of an entire generation of global activists, whose perceptions of the world were undeniably shaped by that singularly stunning image of planet Earth.

The inherent power of imagery is one of the reasons underlying the spirited, and often passionate policy debates over commercial imagery satellites and their impact on US national security. Although the current policy approach—to encourage the growth of the domestic remote-sensing market—is a gamble, realistically it is the only game in town. The technologies for many of these satellites either cannot be effectively controlled or already exist well beyond America's grasp. On the other hand, if American firms eventually dominate the global market, the US government will at least have some measure of control over the availability and distribution of the data from these satellites.

The Role of Government

Consistent with the long-term policy goals of PDD-23, the federal government should continue its efforts to encourage domestic growth of the remote-sensing market. On a case-by-case basis, the government may want to consider underwriting private development of new technologies and applications that hold particular promise for specific government requirements. By integrating the best of what the market has to offer with that of its national reconnaissance systems, the United States can slow or perhaps even prevent the erosion of American information dominance in space-based imagery intelligence, surveillance, and reconnaissance.

Nonetheless, the United States must resist the temptation to be too generous with governmental contracts for remote-sensing products and services. With its enormous buying power and influence over markets, the government could create a destructive codependency that could diminish incentives for innovation and encourage governmental intrusiveness and regulation. For that reason, the challenge for policy makers will be to balance the country's legitimate security concerns against the requirement for robust American competitiveness. Policy makers will simply have to trust in the self-regulating dynamics of the market for high-resolution satellite imagery and hope that it will contribute more to the maintenance of peace than to provoking conflict.

Negotiation over Negation. Although there is great temptation to address the threat posed by commercial imagery satellites with ASAT weaponry, their use could actually encourage others to place US satellites and/or ground infrastructures in jeopardy. A better approach would be US sponsorship of a legally binding treaty on the rights and obligations of remote-sensing countries with respect to data distribution. Such a treaty would require, inter alia, that sensing states possess the capability of exercising shutter control when the collection and/or dissemination of imagery data could harm another state while not depriving legitimate users of data they require. This multilateral device would complete what PDD-23 unilaterally began, enabling the US government to manage the security threat without placing American industry at a disadvantage or risking international rebuke.

Third-Wave Warfare. As the United States is carried ahead by the third wave as a postindustrial state, it can capitalize on its technological supremacy to obviate or reduce the need to rely on the tired strategies and structures of second-wave land warfare. Current joint operational doctrine, however, presumes that America can continue to use the strategies of the past, and as Maj Gen Chuck Link, USAF, Retired, has summarized, tries to "put the highest number of America's sons and daughters in range of enemy fires in as short a time as possible."[72] Still, there is an alternative.

The United States can shed its legacy construct and recognize that large maneuver forces are rapidly becoming a "sunset" capability in the age of information dominance, stealth, and unprecedented battle-space lethality. Advanced technologies offer another approach to warfare, one where force is applied precisely to the vital nodes of an enemy from remote platforms. This new vision brings with it the ability to apply full spectrum dominance to the battle space in a manner that will lessen much of the current apprehension over America's growing vulnerability to satellite observation and targeting. Thus, the debate over high-resolution imaging satellites and the threat they pose really has much more to do with the preferred structure of the US military and the nature of future conflicts than with the capabilities of the satellites themselves.

Is the Sky Falling?

Ultimately, the existence of high-resolution commercial imagery satellites is simply a fact of life that US policy makers will have to accept. Although the information they will provide will undoubtedly offer many challenges in the years ahead, in some respects these high-tech gadgets merely represent the latest iteration in man's struggle to achieve relative advantage over one another. What often happens when a new technology is developed is that the anxiety and fear it generates is followed in quick succession by relief and optimism when another technological innovation cuts short the relative advantage of the first.

This is the classic measure/countermeasure problem.

So, is the "sky falling" because of these new sentinels rising? The answer is complicated because these technologies are neither revolutionary nor inconsequential. Nevertheless, in the near term, the United States should not witness a fundamental alteration in the status quo, although the long-term prospects are less clear. In the final analysis, however, changes in the geostrategic landscape of the multipolar world will have far more impact on US national security than will any of the current or planned capabilities of commercial imagery satellites. □

Notes

1. The SS-25 is a three-stage, solid-fuel, road-mobile intercontinental ballistic missile (ICBM) that continues to serve in large numbers in Russia's nuclear arsenal. In its Start-1 configuration as a space launch vehicle, the missile incorporates an additional fourth stage used to boost the satellite payload into orbit. It is assembled at the Votkinsk Machine Building Plant—the same facility that produces the SS-25 ICBM, SS-27 (Russia's newest ICBM), and also built the infamous SS-20 IRBM banned by the 1987 Intermediate Nuclear Forces Treaty. The Russian development of the Start-1 space launch vehicle (as well as the Rokot, an SS-19 ICBM variant) precipitated a lengthy dispute between the United States and the Russian Federation over the accountability of space launch vehicles that incorporate the first stages of ICBMs or submarine-launched ballistic missiles (SLBM). Prior to signing Joint Statement 21 to the START Treaty in Geneva on 28 September 1995, Russia objected to the US position that a ballistic missile declared as a space-launch vehicle, but that incorporated a first stage of an ICBM or SLBM, was subject "to the provisions of the Treaty relating to ICBMs or SLBMs as an ICBM or SLBM of that type." Had the Russian position prevailed, these missiles could have been removed from accountability by declaring that they were space-launch vehicles. The Russian assertion now threatened to unravel the START verification regime and derail negotiations for deeper nuclear weapons reductions, but would have also opened up an enormous loophole for the proliferation of ballistic missile technology under the pretext of peaceful space launch activities.

2. "Russia Lofts U.S. Imaging Satellite," *Aviation Week & Space Technology* 148, no. 1 (5 January 1998): 29.

3. "Satellite Answers," *Aerospace Daily* 185, no. 6 (12 January 1998): 43.

4. See William E. Stoney, "Outlook for the Future: Land Sensing Satellites in the Year 2000," in *The Remote Sensing Tutorial On-Line Handbook* [CD-ROM], ed. Nicholas M. Short Sr. (Greenbelt, Md.: National Aeronautics and Space Administration Goddard Space Flight Center, 1998), 1–7.

5. "U.S. Policy on Foreign Access to Remote Sensing Space Capabilities," Presidential Decision Directive INSC-23, in *Commercial Remote Sensing in the Post-Cold War Era*, Joint Hearing before the Committee on Science and Technology and the Permanent Select Committee on Intelligence, 103d Cong., 2d sess., 9 February 1994, 160–62.

6. Public Law 102-555 (15 U.S.C. 5601, sec. 2, Findings) cited in Jeffrey A. Jackson, "U.S. Commercial Remote Sensing: Policy, Evolution and Its Implications," research paper, US Air Force Institute for National Security Studies, USAF Academy, Colorado, 21 August 1997, 14.

7. This practical argument is central to US policy toward the commercialization of space. To maintain a competitive and potentially dominant market position, US firms must not be impeded by regulatory risk. (See J. Laurent Scharff, "News Dissemination of Images from Remote Sensing Satellites: First Amendment Standards for Judging National Security Risks," in *Space Imagery and News Gathering for the 1990s: So What?* Proceedings from the Symposium on "Foreign Policy and Remote Sensing" held at the Patterson School of Diplomacy and International Commerce in Lexington, Kentucky, 24–25 February 1989, ed. Robert A. McDonald (Bethesda, Md.: American Society for Photogrammetry and Remote Sensing, 1991), 49.

8. Robert A. McDonald, "Corona, Argon, and Lanyard: A Revolution for US Overhead Reconnaissance," in *Corona between the Sun and the Earth: The First NRO Reconnaissance Eye in Space*, Robert A. McDonald, ed. (Bethesda, Md.: American Society for Photogrammetry and Remote Sensing, 1997), 70–71; and National Reconnaissance Office, Historical Imagery Declassification Fact Sheet, available from http://www.odci.gov/corona/facts/htm; Internet accessed 6 October 1997.

9. Robert A. McDonald, "Corona Imagery: A Revolution in Intelligence and Buckets of Gold for National Security," in McDonald, 211–15.

10. Ann M. Florini, "The Opening Skies: Third-Party Imaging Satellites and U.S. Security," *International Security* 13, no. 2 (Fall 1988): 97–98. The ability to discern detail in an image and derive militarily significant information is not entirely determined by the spatial resolution of an image. Imagery analysts use other techniques that can lead to identifying unique signatures for natural and man-made objects and include shape, size, tone, texture, pattern, shadow, site, scale, and association.

11. Peter D. Zimmerman, "Introduction to Photo-Interpretation of Commercial Observation-Satellite Imagery," in *Commercial Observation Satellites and International Security,* ed. Michael Krepon et al. (London: Macmillan Press Ltd., 1990), 201–3.

12. Ibid., 204.

13. US Air Force Space Command, Operation SEEK GUNFIGHTER—Aggressor Space Applications Project Operational Report (Colorado Springs, Colo.: Falcon Air Force Base, 23 January 1998), 2–4.

14. Ibid., 4.

15. Ibid., 7–15.

16. Ibid., 16.

17. Dr. John R. Schott, director, Rochester Institute of Technology's Center for Imaging Science, interview by author, Rochester, N.Y., 23 January 1998.

18. Aegis Research Corporation, "Military Impact of Commercial Satellite Imagery" (Washington, D.C.: Aegis Research Corporation, 19 June 1997 [photocopied briefing slides]), 6–7.

19. For an excellent treatment on the subject of GPS and national security concerns, see Irving Lachow, "The GPS Dilemma: Balancing Military Risks and Economic Benefits," *International Security* 20, no. 1 (Summer 1995): 126–48.

20. Ibid., 127.

21. Ibid., 129–30.

22. Pierre C. Robert, "Remote Sensing: A Potentially Powerful Technique for Precision Agriculture," in *Proceedings of the Land*

Satellite Information in the Next Decade II: Sources and Applications Symposium, Washington, D.C., 2–5 December 1997 [CD-ROM] (Bethesda, Md.: American Society for Photogrammetry and Remote Sensing, 1997), 1–4.

23. Alvin and Heidi Toffler, *War and Anti-War: Survival at the Dawn of the 21st Century* (Boston: Little, Brown and Company, 1993), 3.

24. Rep. Larry Combest (R-Tex.), ranking Republican on the House Permanent Select Committee on Intelligence, used this example during a 1994 congressional hearing on remote sensing. He also acknowledged, however, that the United States does not have the ability to eliminate the security threat when he said, "We know the power of this technology, and we wish to delay as long as possible the day when it will be used against our own sons and daughters." (See House Committee on Science, Space, and Technology and the Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post–Cold War Era: Joint Hearing before the Committee on Science, Space, and Technology and the Permanent Select Committee on Intelligence*, 103d Cong., 2d sess., 9 February 1994, 20.)

25. Bob Preston, *Plowshares and Power: The Military Use of Civil Space* (Washington, D.C.: National Defense University Press, 1991), 35–42.

26. Richard K. Betts, *Surprise Attack: Lessons for Defense Planning* (Washington, D.C.: The Brookings Institution, 1982), 18.

27. House Committee on Armed Services, Subcommittee on Oversight and Investigations, *Intelligence Successes and Failures in Operations Desert Shield/Storm*, prepared by Warren L. Nelson and others, 103d Cong., 1st sess., August 1993, 3.

28. Carl von Clausewitz, *On War*, with an introduction by Anatol Rapoport, ed. (London: Penguin Books, 1968; original translation published by Routledge & Kegan Paul Ltd., 1908), 119

29. E. Marshall, "Space Cameras and Security Risks," *Science* 243 (January 1989): 472–73, cited in *Space Imagery and News Gathering for the 1990s: So What?* 3.

30. Office of Technology Assessment, *Commercial Newsgathering from Space—A Technical Memorandum*, OTA-TM-40 (Washington, D.C.: Government Printing Office, May 1987), 1.

31. Ibid., 30.

32. *War and Anti-War*, 139–42.

33. John W. Rendon Jr., "The Information Warrior," in *The Information Revolution and National Security: Dimensions and Directions*, with a foreword by Adm William A. Owens, ed. Stuart J. D. Schwartzstein (Washington, D.C.: Center for Strategic and International Studies, 1996), 61.

34. Stephen A. Cambone, *Kodak Moments, Inescapable Momentum, and the World Wide Web: Has the Infocomm Revolution Transformed Diplomacy?* (McLean, Va.: Center for Information Strategy and Policy, Science Applications International Corporation, September 1996), 16–17.

35. William R. Harris, "Soviet Maskirovka and Arms Control Verification," in *Soviet Strategic Deception*, Brian D. Daily and Patrick J. Parker, eds. (Lexington, Mass.: Lexington Books, 1985), 195–96.

36. Lewis A. Dunn and Marjorie Robertson, *Satellite Imagery Proliferation and the Arms Control Intelligence Process* (McLean, Va.: Science Applications International Corporation, 22 April 1997), 11.

37. For an excellent survey of international initiatives for satellite organizations, see Péricles Gasparini Alves, *Prevention of an Arms Race in Outer Space: A Guide to Discussions in the Conference on Disarmament* (Geneva, Switz.: Institut des Nations Unies pour la Recherche sur le Désarmament, 1991), 107–30. One of the best sources on satellite imagery, the media, and the Mediasat concept is the report by the congressional Office of Technology Assessment (see *Commercial Newsgathering From Space*).

38. Dunn and Robertson, 12.

39. Ibid., 13–14.

40. J. Christian Kessler, *Verifying Nonproliferation Treaties: Obligations, Process, and Sovereignty* (Washington, D.C.: National Defense University Press, 1995), 11.

41. Harris, 197.

42. John J. Dziak, "Soviet Deception: The Organizational and Operational Tradition," in *Soviet Strategic Deception*, 42.

43. Amrom Katz, *Verification and SALT: The State of the Art and the Art of the State* (Washington, D.C.: Heritage Foundation, 1979), 20.

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